Geology of Vasquez Rocks

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Aerial view of the majority of Vasquez Rocks Natural Area Park, with State Route 14 Freeway visible in the lower right and Escondido Canyon Road (the road used to access the park) visible in the upper left. Note clearly visible sandstone layers which form the unique and dramatic landscape. Image ©Google Maps, 2016.

The Rocks are located in what is known as the Soledad Basin, which sits cradled to the south of the smaller **Sierra Pelona Mountains**, and to the west and north of the more well-known, larger **San Gabriel Mountains**. **Soledad Canyon** runs to the south of the park, **Mint Canyon** runs to the north, and **Agua Dulce Canyon** runs north to south right through the Vasquez Rocks area.

The distinctive formations in the Vasquez Rocks area were actually formed through a relatively simple process, and the clues to its creation are still visible all around. Over the course of the past 25 million years (the most commonly agreed-upon age by geologists), vast amounts of sediment (sand, soil, rocks, and organic materials) were brought downward into the Soledad Basin by events such as rains, flooding, landslides, wind, and earthquakes from the surrounding San Gabriel and Sierra Pelona Mountains. As these materials were deposited on the basin's floor, they would settle flat on the ground surface, and as years passed, new deposits covered the older ones, eventually placing them under tremendous amounts of pressure. With this pressure, the deeper layers became solidified, turning into what we know as sandstone.

One of the most commonly photographed views of the “Main Rock” looking toward the northwest. Note the severity of the angles of the varying layers, which include sandstone of different colors and hardnesses. For references in the following pictures in the report, the Main Rock, as do most of the rocks in the formation, point toward the northeast. Photograph by Sarah Brewer, 2012.

As these layers were deposited during separate periods by different events, they have created a physical record of the weather and atmosphere during the periods in which they were created. For example, much the way tree-ring dating allows us to see years that had a lot of precipitation, or years that were dryer, these layers in the sandstone can be read to figure out the relative age of events. Because the layers are made of inorganic materials, they cannot be dated using technology such as radiocarbon dating, but we are able to see which events happened before or after others, allowing us to construct a timeline for how the layers were formed. Dry, stable periods made for relatively uneventful (or nonexistent) layers in the sandstone, while extremely dramatic years, such as those with heavy floods or landslides, resulted in the opposite: thicker, more complex and dynamic layers, which can contain various other minerals or even larger pieces of existing rocks. These layers that contain other rocks (which range in size from small pebble to large boulders) can be seen throughout the park. The combinations of these different textures and colors result in the fascinating layer-cake look to the formations in the park.

Aside from this area where massive sandstone slabs were formed, the Vasquez Rocks area is also located in an extremely geologically active area in terms of earthquake activity. The famous San Andreas fault, which divides the massive North American and Pacific tectonic plates runs through the towns of Acton and Palmdale, only miles from the Vasquez Rocks area. An offshoot of the San Andreas, known as the Elkhorn Fault, actually runs right through the park and has resulted in a large amount of movement over millions of years.

While there are countless smaller layers visible throughout the park, there are three main formations to know, which contain these smaller (unnamed) layers. The **Lower Vasquez Formation** is the oldest, with geologists estimating an age of approximately 25.6 to 23.6 million years old, and a thickness of approximately 1,300 meters or 4,200 feet. The **Vasquez Formation** lays on top of the Lower Vasquez Formation. It is approximately 5,800 meters (or 19,000 feet) in thickness and is approximately 20 million years old. The newest formation visible in Vasquez Rocks is the **Mint Canyon Formation**, which is approximately 1,550 meters, or 5,000 feet, in thickness, and 10-16 million years old.

After the deposited layers of sand and sediment were "lithified" (turned to stone), large amounts of earthquake activity cause major disturbances to the previously flat stone. Due to the park's location along the **Elkhorn Fault**, an offshoot of the massive **San Andreas Fault**, earthquakes have been a very stable occurrence for millions of years, where constant movement and pressure have led to extreme lift. Typically, the rocks point toward the north, at angles ranging from around 40-52 degrees. It is estimated by geologists that parts of the formation also go down to incredible depths: approximately 22,000 feet, or around 4 miles.

These steep formations erode as they are exposed to the elements, and because the varying layers of the sandstone are composed of alternative soft and hard layers, they erode at different rates. This creates a layered effect of sometimes sharply angled rocks that rise prominently toward the sky. These types of jagged formations are sometimes referred to as "**hogs back ridges**" due to their jagged, sometimes vertebral-looking shape. As you walk around the park, take notice of these sharper rocks, but also observe how those nearby may be a softer, more rounded shape- it all depends on the types of weathering that each particular part has encountered and how susceptible they are to wearing down.

The Rocks range in size and angle severity, but for reference, the "main rock", located in the middle of the park and the most iconic of any parts of the formation, rises above the ground below over 150 feet. Though not the highest point in the park, it certainly demonstrates the incredible height and angles that the formation features.

As with anything of such an ancient age, they have persevered but are always changing. Exposure to the elements breaks and shapes the rocks, which complete its circle and eventually becomes sand once again. Through erosion, the rocks become smaller as centuries pass, and they become rounded and smoothed from wind and rain. It is interesting to think about what the rocks looked like 500, 5,000 and 5,000,000 years ago, and what they will look like in the distant future.

Useful Geology Terms & Photographic Examples

Whether you are studying this geology for a class, or simply interested in learning more about the park around you, these geological terms can help you better understand the aspects of Vasquez's Rocks interesting geology.

Alluvial Fan: Sediment, including sand and rocks, that wash down from the mountains (in this case the San Gabriel Mountains) and are deposited over plains or valleys. The word "fan" indicates that these deposits are typically fan shaped, coming down from many avenues on a mountain/several mountains, to a smaller, more narrow bottom point in the valley floor below.

Conglomerate: A sedimentary rock, in this case sandstone, which was formed with inclusions of other rocks. These rocks can be sedimentary, igneous, or metamorphic, and can range in size from small pebbles to large boulders. Notice in the Park that you will see small to large-sized granite rocks situated within the sandstone layers. It's interesting to think that these rocks are much older than the "matrix", or main sandstone rock around them- these rocks were already fully formed as the sandstone was just being deposited!

An example of a **conglomerate** later located near the center of the park. The green arrow notes the conglomerate layer, which contains various complete rocks, including small granite boulder. Note that this layer is largely intact and is of a stronger material than the layers above and below it. For comparison, the yellow arrow notes a more fine-grained layer that has eroded away more quickly due to its relative softness compared to the surrounding layers (see **Differential Erosion**). Photograph by Sarah Brewer, 2012.

***Desert Varnish**:* On the top of some rock outcrops are blackish deposits of clay minerals (with manganese, which provides a black color, and iron which provides red), which have been weathered out of the rock by the heat of the sun. Surfaces of pebbles, boulders, and rock outcroppings that are exposed to the sun may become darkened by this film of oxidized chemicals. Colorful formations such as these are called "desert varnish" because of their dark, paint-like appearance.

Left: **Desert varnish** as it appears on the reddish colored sandstone, which is part of the older Lower Vasquez Formation. The minerals from within the sandstone were affected by moisture and heat over time, resulting in thickened, almost paint-like darkening on the surface of the rock. As these minerals form a layer that is usually harder than the sandstone, it is often stronger than the rock underneath and often slows erosion on certain areas of the stone (see **Differential Erosion**). This phenomenon is found throughout the park, with some rocks having a large amount of the desert varnish covering their surfaces, giving them a dark, painted appearance. Photograph by Sarah Brewer, 2014.

Differential Erosion: The erosion of only softer, nonresistant portions of the rock or other material, with surrounding layers (which may be harder or more compact) eroding more slowly. This effect creates some of the most interesting shapes and textures within the formations at the Rocks. The effect of the desert varnish is another example of differential erosion on a smaller scale.

Right: Millions of years of **differential erosion** have resulted in some very interesting shapes in rocks throughout the park. Pictured here is a large, unique out-cropping, which is located off of the Pacific Crest Trail in the southeastern portion of the park. Photograph by Sarah Brewer, 2012.

Displacement: Geologic movement or shifting or objects such as rocks or portions of rock formations.

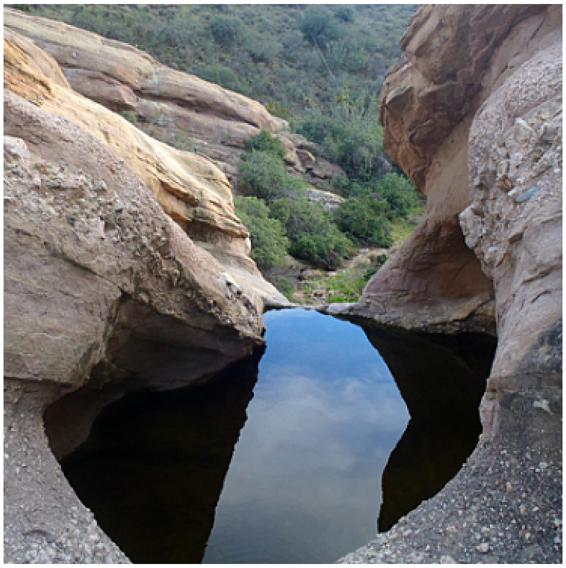
Erosion: the breaking down and removal of material by various processes, such as the wearing away of rock by water running over its surfaces, wind, heat, and cold temperatures. This process completes a cycle of sorts of the "life" of sandstone- just as it was made from sand, it gradually returns to sand as it erodes.

A favorite spot for visitors of all ages, the "Witch's Hat" rock, located off of the Nature Heritage Trail near the front of the park is an excellent example of the effects of weathering and **erosion** on the rock. Note the roundness of the edges on the rocks, which have been worn down over time from wind, rain, human activity, and other erosional forces. Photograph by Sarah Brewer, 2016.

Fanglomerate: Coarse-grained rock, similar to conglomerate, but with pebbles which are more angular, with corners and edges; these were originally deposited in an alluvial fan. These typically indicate a more violent, heavier, and faster episode, such as a raging flood that carried a lot of material down without allowing it time to become weathered and rounded.

Fault: Fracture where once-whole rocks suffered displacement. Earthquakes are caused by the movement of landmasses along fault lines and the friction between the land masses as they move.

Solution Holes: Occur when water flows over, or is left standing in, small depressions in the rocks. Over time, the water dissolves some of the rock's minerals, which are later carried away by rain, wind, and other erosional forces. Eventually, a solution hole may develop, which over time can grow from the size of a small pebble to the size of a school bus or larger! These solution holes, combined with differential erosion, have created interesting shapes in the rocks throughout the park.



Left: An example of a larger **solution hole** in the rock, which is large enough to form a natural water catch basin. During seasons with sufficient rain, it serves as a welcome watering hole for animals, and also served as a perfect place to take a dip for some of the area's earlier residents. Right: An example of an outcropping showing the various **strata** (layers) that make up the sandstone. Photographs by Sarah Brewer, 2011/2014.

Strata: Layers or sections of deposited material such as rocks or alluvial sands. These layers are what give the formations their “layer cake” appearance.

Another example of the forces of erosion on the varying strata of the sandstone. Note the smoothed appearance of the layers which have been worn by millions of years of factors like rain and wind. Photograph by Sarah Brewer, 2016

Lichen: While visiting the park, you may also notice various colors of what resembles paint on the rocks. Ranging from orange and yellow to mint green and grey, these colorful patches are actually living organisms. These "composite" organisms are a combination of fungus and algae, which require nothing more than clean air, a little bit of moisture, and a host surface to hold onto. As they grow incredibly slowly, please be careful while climbing on rocks with this extra splash of color.

Examples of the colorful lichen organisms that thrive at Vasquez Rocks. As they are extremely slow growing, they should be admired without being touched. Photographs by Sarah Brewer, 2016.